Direct Numerical Simulation of Halite Cementation: Towards a Model to Predict the Location of Halite Fingers in Hydrocarbon Reservoirs

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ABSTRACT

Halite cementation is a major exploration risk in hydrocarbon reservoirs. Halite-cemented reservoir zones suffer from very low porosity and permeability due to the partial or complete occlusion of the pore space. Despite being a key process that affects the quality of the productive formation, a quantitative analysis of the physical process responsible for halite cementation is still missing in the scientific literature. Brine reflux-caused density gradients are one of the main physical mechanisms responsible for the intrusion of salt in the pores of a productive formation. Physically, the dissolution of salt by the resident brine creates a zone of higher density which may give rise to the development of flow instabilities. Small perturbations in the initial setting may lead to sensibly different final patterns. A prominent example is the behavior of salt and fresh water where salt water layered on top of fresh water shows unstable salt water fingers intruding into the fresh water whereas salt water layered below fresh water shows no fingering. The first configuration is physically unstable while the latter is stable. In most models of halite cementation formed by density driven flow, dense water is assumed to flow downward uniformly. However, even when reservoir properties are homogeneous, the unstable behavior of density driven flow may still cause heterogeneous distribution of halite cements. In this work we present a quantitative methodology for estimating halite-cemented zones by means of numerical simulation for different flow and rock parameters. We first identify the main nondimensional groups that govern the flow. We analyze the impact of these parameters in the finger distribution and develop a statistical methodology to obtain a finger spacing distribution given a choice of nondimensional groups. We finally develop a simple linear model and a search table that may be used to predict finger spacing.